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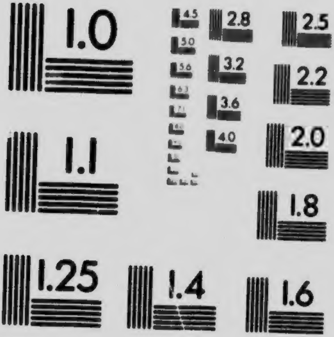

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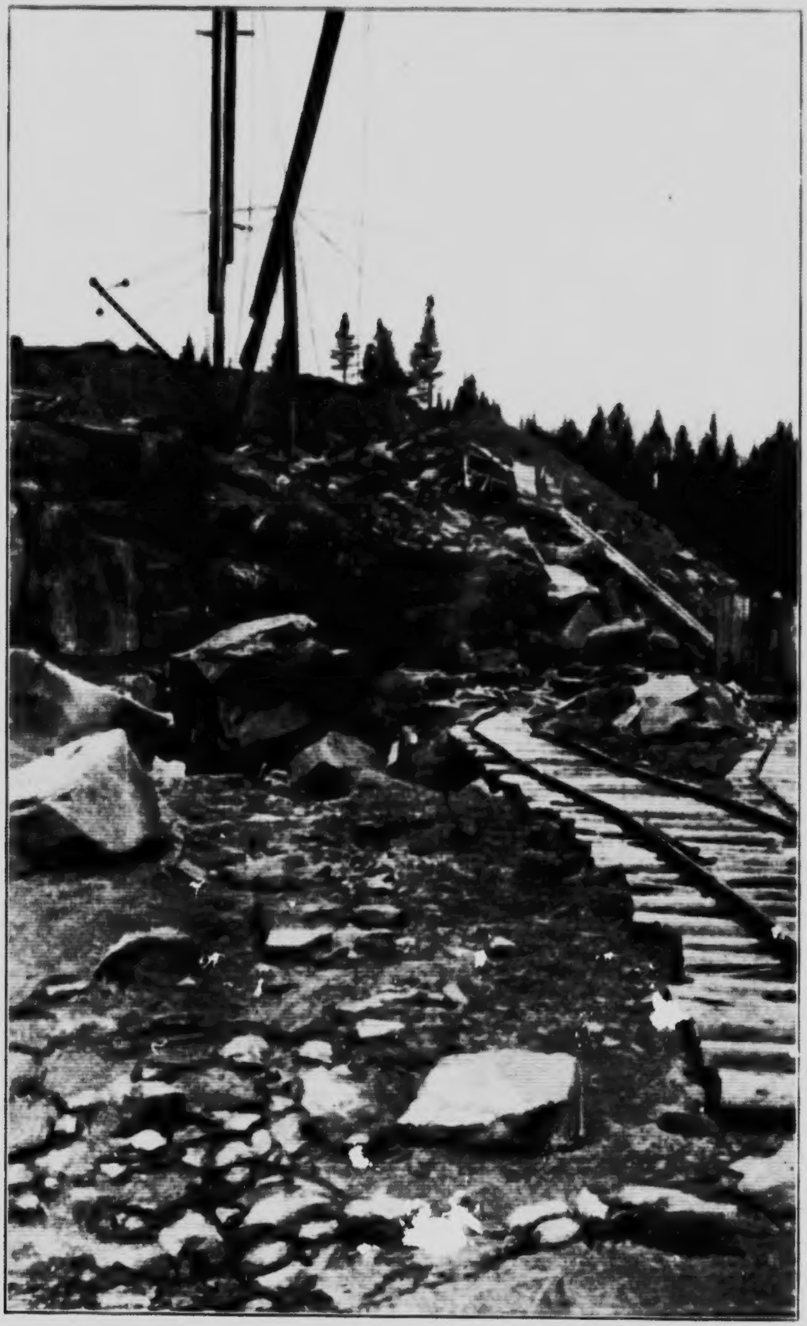
BULLETIN No. 19

Test of some Canadian Sandstones to Determine their Suitability as Pulpstones.

BY
L. Heber Cole

OTTAWA
GOVERNMENT PRINTING BUREAU
1917

No. 466



General view, Miramichi Quarry Co., Ltd., Quarryville, N.B.

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29608c

No. 466

LETTER OF TRANSMITTAL.

DR. EUGENE HAANEL,
Director Mines Branch,
Department of Mines, Ottawa.

Sir,—

I beg to submit herewith the final report on the results of tests of several Canadian sandstones, as to their suitability for use as pulpstones.

I have the honour to be,
Sir,
Your obedient servant,
(*Signed*) **L. H. Cole.**

Ottawa, August 20, 1917.

CONTENTS.

PAGE
Introductory....... 1
Pulpstones.—
  General description, dimensions, etc., and stresses to which they are subjected. 1
  Properties of a good pulpstone....... 4
Canadian Sandstones.—
  Localities visited, and sampled:—
    Ontario....... 6
    Quebec....... 6
    The Maritime Provinces....... 6
Method of manufacturing pulpstones....... 9
Tests to which samples were subjected.—
  Granulometric analysis....... 10
  Hardness test, (Dorry Hardness Machine)....... 11
  Toughness test, (Page Impact Machine)....... 11
  Microscopic examination for structure....... 12
Results of tests.—
  Table I. Granulometric analyses....... 13
  " II. Cumulative percentages, Canadian and imported pulpstones....... 13
  " III. Hardness test....... 14
  " IV. Toughness test....... 14
  " V. Microscopic examination....... 14
Conclusions to be drawn from results of above tests....... 15
Suggested course for future investigation....... 16
Index....... 17

ILLUSTRATIONS.

Photographs.

Plate I. General view, Miramichi Quarry Co., Ltd., Quarryville, N.B.....Frontispiece
" II. Method of preparing pulpstones....... 6
" III. Lower beds—Miramichi Quarry Co., Ltd., Quarryville, N.B. (These beds of sandstone are from 10 to 12 feet in thickness)....... 6
" IV. View showing sandstone beds, Adam Hill's quarry on northwest Miramichi river, New Brunswick....... 8
" V. View in Miramichi Quarry Co's. quarry—showing upper sandstone beds and thickness of overburden....... 8
" VI. Microphotographs of grinding faces of Canadian sandstones and imported pulpstones: showing relative grinding qualities. Magnification—12 diameters oblique reflected light....... 16

Drawings.

Fig. 1. Wood grinder—side elevation of standard 3-pocket grinder....... 2
" 2. Wood grinder—sectional elevation showing method of securing stone on shafting....... 3
" 3. Pulpstone, 27" × 54"....... 4
" 4. Graphic comparison of screen analyses of Canadian sandstones, with average analysis of seven imported stones....... 16

TEST OF SOME CANADIAN SANDSTONES TO DETERMINE THEIR SUITABILITY AS PULPSTONES.

INTRODUCTORY.

The Great War has demonstrated to Canadians the pressing need of a more vigorous investigation and exploitation of the natural resources of the country, with a view to supplying the growing industries with raw materials and the factories with appliances, etc., commodities which have, heretofore, been largely imported. The need is all the greater when it is considered that, even after the war is over, it will be a number of years before it will be feasible to import goods from either Great Britain or the United States at anything like the freight rates and prices which existed prior to the war. In many cases it has already been found that Canada contains materials within her borders, which have been proved by examination and test, to be in every way the equal, in quality and adaptability, of the imported product; and which, in many cases, can be produced at a considerably less cost than the original, pre-war cost of the imported article.

With a view to determining whether Canadian Sandstones would not be suitable for use as wood pulp grinders, the writer was instructed by the Director of the Mines Branch, Ottawa, to investigate certain sandstone areas in the Maritime Provinces and other parts of eastern Canada; to procure samples from such as appeared promising; to test the same; and to prepare a report on the results obtained. It was conceived that two purposes would be served by such an investigation: (1) to locate a Canadian source for supplying pulpstones to the pulp mills, to make up for the serious shortage caused by the impossibility of obtaining, at reasonable prices, stones from Great Britain and the United States; and (2) to suggest to the sandstone quarry owners, a possible market for their product, and thus encourage and assist a comparatively new branch of the industry in Canada.

The following report is the result of the investigation and tests.

PULPSTONES.

In order that intending producers of grinding stones may have some technical idea of the work required from a stone, and the stresses and strain to which it is subjected when in actual operation, the following brief description is given of the process of manufacturing wood pulp.

The mechanical process of producing cellulose fibres for paper making, consists,—after cutting the wood into short lengths or bolts, and removing the bark—of grinding the wood into a fine pulp fibre by means of a large rotating stone. To obtain as long, thin, and flexible a fibre as possible, the wood bolts are pressed against the curved face of the stone with their longitudinal axis parallel to the shaft turning the stone. The bolts are held against the stone by hydraulic pressure, applied by means of plungers. Figs. 1 and 2, show two diagrammatic views of a standard, 3-pocket, pulp grinder. The wood bolts are fed into the three pockets, hence there are, at the same time, three grinding points on the stone. Machines of this type employ stones varying from 26″ to 34″ thick and 54″ diameter. The standard size is 27″ by 54″—as shown in Fig. 3.

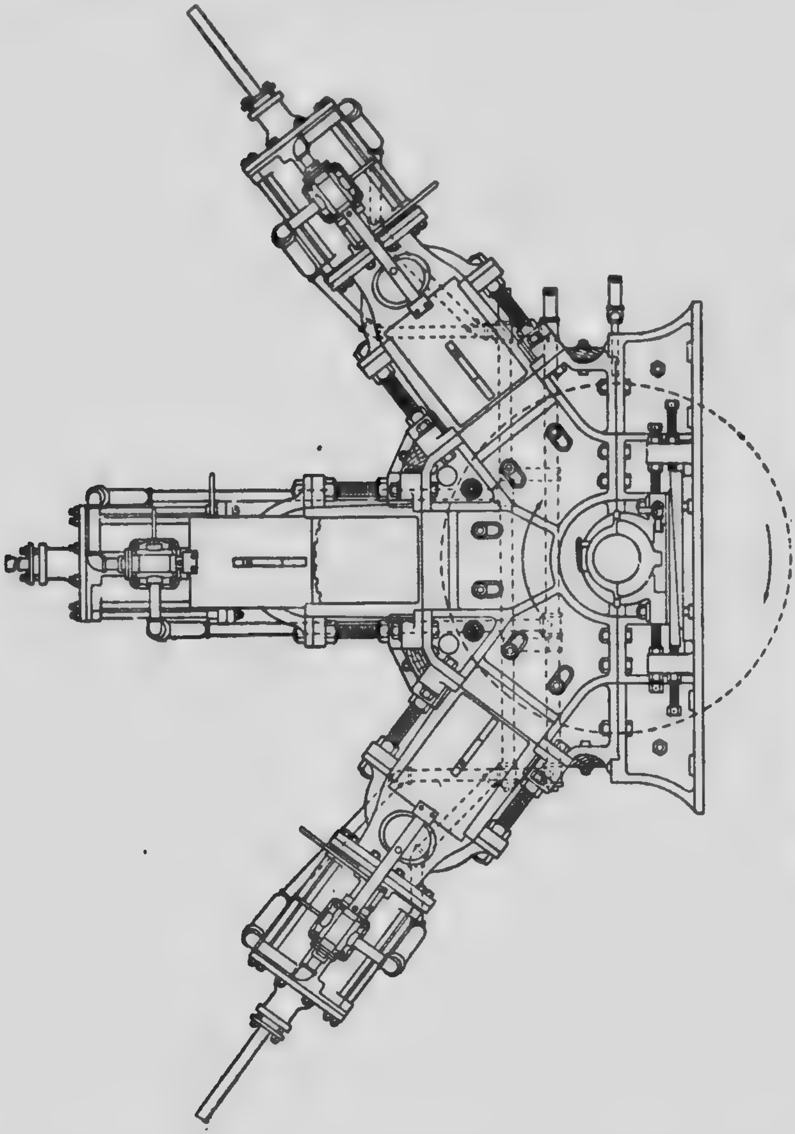

Fig. 1. Wood grinder, side elevation of standard 3-pocket grinder.

The stresses to which a stone in a machine of this type is subjected, can readily be seen. The centrifugal force of the rotating stone; the friction on the grinding face caused by the pressing of the bolts on the surface under heavy pressure; the pressure on the sides of the stone by the flanges which hold it to the shaft—including the driving force; and the expansion and contraction strains due to the uneven heating of the stone by the heavy friction: thus, the complicated nature of the stresses which a stone has to withstand can readily be imagined. With a magazine grinder—which employs a stone 54″ thick by 62″ diameter, the stresses are still further complicated, since only two pockets are employed, and these are directly opposite each other. In this case, an extra stress is developed, due to, the pressure of the bolts on opposite sides of the stone. At any moment of the stone's rotation, there is a tendency for the shape of the stone to be somewhat altered and assume—due to this lateral pressure on each side—the form of an ellipse, with the longer axis vertical. This causes the development of tension in certain parts of the stone; while other parts are subjected to compression. As the stone is rotating at a rapid rate, that part, which one moment is in compression, passes rapidly into tension, and vice versa. Consequently, any part of the stone is constantly alternating from one to the other, as well as being subjected to the strains and stresses already mentioned.

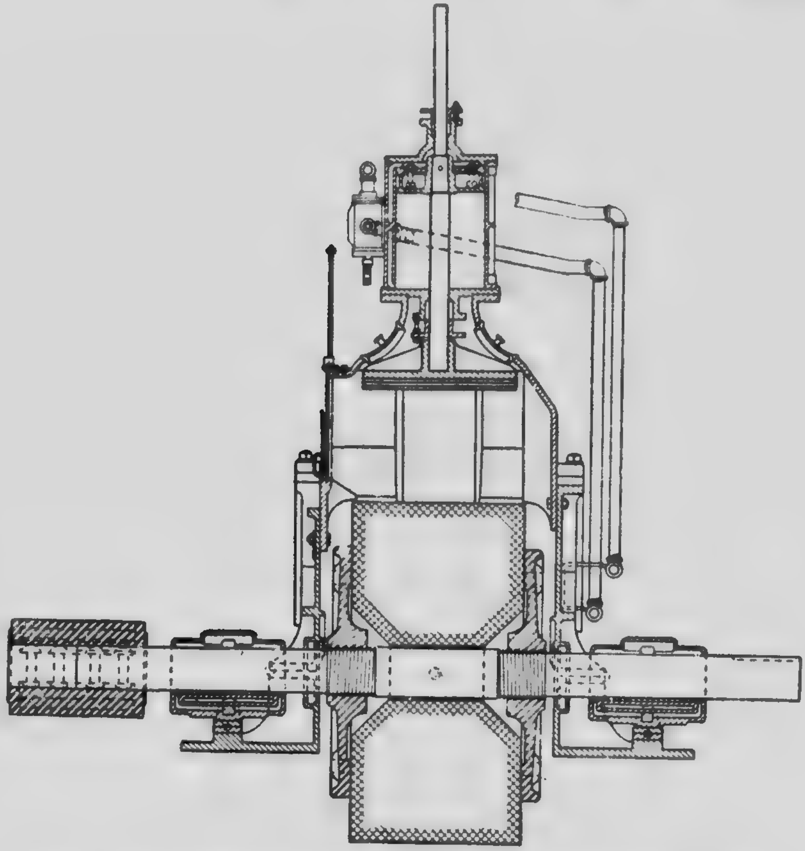

Fig. 2. Wood grinder, sectional elevation showing method of securing stone on shafting.

The speed at which the stone is rotated will vary in different mills but will generally range from 200 to 225 R.P.M.; while the pressure in the cylinders will vary from 60 to 125 lbs. per square inch. The stones range in weight from 2 to 4 tons. From these figures it will readily be seen to what enormous strains the stones are subjected.

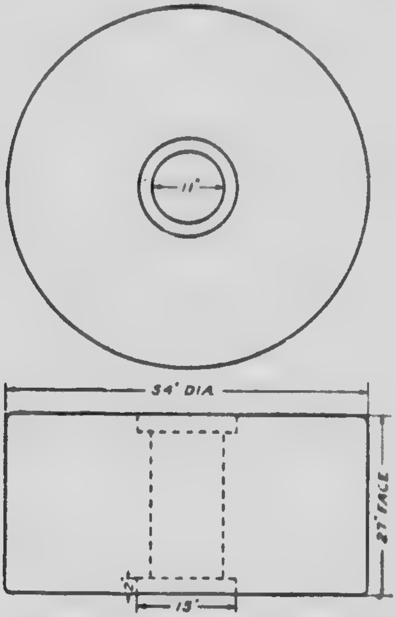

Fig. 3. Pulpstone 27" × 54".

The life of a good stone seems to be about one year, and in this time it will wear from 54" down to 40" diameter.

PROPERTIES OF A GOOD STONE.

There are several essential qualities which a sandstone must have in order to be accepted as a good pulpstone; *i.e.*, texture, grinding qualities, and strength.

Texture

In order to produce long, thin, and flexible fibre, the stone must tear the fibres apart, rather than cut, hence a sandstone in which the grains are slightly rounded on the edges, will give better results than one whose particles are ragged and angular. On the other hand, a sandstone with grains perfectly rounded, will tend rather to polish than to cut, and will produce a pulp that is very greatly inferior both in length of fibre and thickness to that produced by a sandstone with sub-angular grains.

Moreover, the size of the grains [illegible] to be taken into consideration. If the grains are coarse, the stone wi[illegible]ut faster, and produce more pulp than where the grain is finer; but the pulp produced in the former case is of poorer quality and coarser texture than when a finer grained stone is employed. Thus the size of grain, as well as its angularity, are both points to be considered.

Grinding Qualities.

In order that a stone may have good grinding qualities the structure of the material should be such, that the matrix or constituent bonding the grains together is softer than the sand grains. Being softer, the matrix will wear away faster, and the sand grains project, leaving the surface of the stone roughened. The stone should be of uniform composition and hardness throughout, otherwise it will wear unevenly and thus reduce its effectiveness. If a stone is too hard, it is liable, apart from cutting and tearing the fibres, to polish smooth, and require frequently to have a fresh grinding face turned on it. On the other hand, if it is too soft, it will wear rapidly and produce less pulp than a stone of average hardness.

Strength.

As already explained, a pulpstone is subjected to considerable stresses and strains, therefore it should be of sufficient strength to withstand these strains, and have a considerable factor of safety.

In briefly summing up the qualities of a good pulpstone, it may be laid down that a sandstone used for this purpose, must be uniform in texture throughout; have grains of angular to semi-angular form cemented together by a softer matrix; have sufficient strength; must be of medium hardness; and the cutting grains must be of a size suitable for producing the grade of pulp required.

CANADIAN SANDSTONES.

In the field work in connexion with an investigation of this nature there are several important points, apart from the characteristics just enumerated, which have to be taken into consideration when examining a possible locality for the quarrying of pulpstones. A stone may fulfil all the physical requirements of a good pulpstone, yet may be lacking in the following features, any one of which would bar it from being employed. The points may be enumerated briefly as follows:—

(1) A quarry must be situated convenient to either water or rail transportation.

(2) The beds must be of sufficient thickness and free from joint planes to enable stones of the required size to be excavated with the least trouble and waste.

(3) The quarry must contain enough stone of the proper thickness and uniformity to warrant operations being carried out on a sufficiently large scale.

(4) The rock when freshly quarried must be of such a nature as to enable it to be easily chipped and turned into the proper dimensions and also harden on being exposed and seasoned for a reasonable length of time.

It can readily be seen that the localities which would fulfil all these requirements would naturally not be very numerous, and in the field work this proved to be the case. The investigation was confined to the eastern part of Ontario, and certain sections in the province of Quebec and the Maritime Provinces. A brief description is given of each of the localities from which samples were taken.

LOCALITIES VISITED AND SAMPLED.

ONTARIO.

In the province of Ontario there are few occurrences of sandstone which would be at all suitable. The Potsdam sandstone which is the most abundant sandstone formation in the eastern part of the province was found to be either too hard or else too friable and in beds badly fractured. Only one locality was deemed worth sampling.

J. C. Higginson Quarry, Hawkesbury, Prescott County, Ont.

On the eastern outskirts of the town of Hawkesbury, Ont., near the C.N.R. Station, an outcrop of sandstone of the Chazy formation is being quarried for use as road material and building purposes. The quarry presents in places a face of 6 feet, the upper three feet being thinly bedded and badly shattered, but the lower bed is in some places fully three feet in thickness. According to Dr. Parks report[1] a well in the vicinity shows that the deposit is fully 50 feet in thickness. A sample from the quarry was taken and tested. (Sample No. 13.)

QUEBEC.

In the province of Quebec, in the area lying southwest of Montreal, between the St. Lawrence river and the international boundary line, a number of outcrops of Potsdam sandstone were examined but no material, suitable for pulpstones was encountered.

THE MARITIME PROVINCES.

The Carboniferous system which contains numerous beds of sandstone, principally in the Permo-Carboniferous and Millstone Grit, is well developed in the Maritime Provinces and since the quarries already opened in these measures show beds of considerable thickness, it was in localities where these formations occur that the most time was spent. In all, about 25 localities were visited, but as many of these could not possibly produce stone suitable for pulpstone, only those from which samples were taken for testing will be described.

---

[1] Report on Building and Ornamental Stones of Canada, Vol. I, No. 100. By Dr. W. A. Parks. Published by Mines Branch, Dept. of Mines, Ottawa, 1912.

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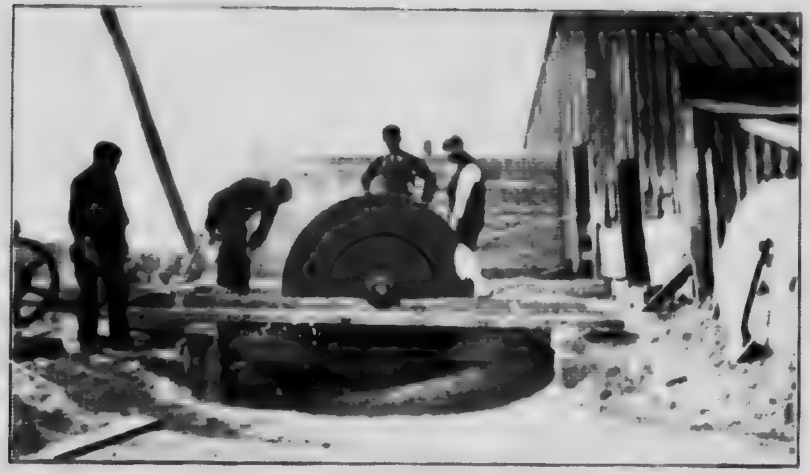

Method of preparing pulpstones.

PLATE III.

Lower beds, Miramichi Quarry Co., Limited, Quarryville, N.B.
(These beds of sandstone are from 10 to 12 feet in thickness.)

Read Stone Company, Sackville, N.B.

Stonehaven Quarries.

These quarries are situated on the south shore of Chaleur bay at Stonehaven, in the parish of New Brandon, Gloucester county. The beds are exposed for a depth of about 70 feet, the lower 15 feet of the excavation being below the high water level of the bay. This has necessitated the building of dams to keep out the water. This work entails heavy expenditure, and would probably be a material factor in the cost of excavating the stones. The lower beds from which the sample was taken have a total thickness, in places, of 15 feet, which, however, is divided into layers from 1 to 3 feet in thickness, so that it is doubtful if any great number of stones of 27″ face could be obtained from this quarry. (Sample No. 10.)

Adam Hill Quarry, Cassils P.O., N.B.

This quarry is not in operation at the present time and the lower beds could not be examined owing to their being under water. The quarry is situated on the north bank of the northwest arm of the Miramichi river, about 9 miles from Newcastle, N.B. The products are shipped down the river by barge to Newcastle, N.B.

The beds are not uniform in character throughout the quarry and vary from 6 inches to 4 feet in thickness. Some of the beds contain "bulls" and coarse streaks which would bar their use for pulpstones, but there are parts of certain beds which would yield blocks of the required size. The sample for testing was taken from one of the larger and more uniform beds. (Sample No. 3.)

The Miramichi Quarry Co., Ltd., Quarryville, N.B.

R. Geo. Hood, President and Managing Director.

Head Office,—10 Richmond Square, Montreal, Que.

The property owned by this company extends from the north shore of the Miramichi river, a little over a mile along the west side of Indiantown brook. The quarry is opened for a length of nearly 300 feet and has been worked back from the edge of the creek for a depth of nearly 200 feet. The total height of the face above the level of the creek is about 100 feet and the following is an average section:—

10–12 feet.	Stripping.
44 feet.	Layers of sandstone varying from 2 to 7 feet thick. Some of these beds are shattered but a considerable quantity of blocks of suitable size for pulpstones could be obtained from them.
11 feet.	Medium grained stone with joint planes 10 feet apart.
2 feet.	Badly shattered section with shale and coal seams.
10 feet.	Medium grained stone with joint planes 10 to 12 feet apart.
20 feet.	Covered with talus and broken rock.

The beds vary somewhat in texture, and tend to be coarser towards the bottom. Some of the beds show the presence of "bulls" which consist of the stone hardened by local crystallization; in some cases the partings are filled with mud or carbonaceous material, which also occasionally occurs in their veinlets through the beds. From the whole, however, with careful selection, a large tonnage of stone could be obtained of suitable dimensions.

This quarry is already equipped with the necessary apparatus for preparing pulpstones and has, moreover, been manufacturing these stones in a small way for the past 15 or 20 years. The stones from this quarry have been used in several of the Canadian pulp mills and have apparently given satisfaction for the class of work for which they were employed. The sample for testing was taken from the lowest bed exposed. (Sample No. 4.)

Read Stone Company, Sackville, N.B.

Indiantown Quarry, Quarryville, N.B.

This quarry has been opened within the last couple of years, but already a face of 30 feet high is exposed. The property is situated on the east side of Indiantown brook, directly opposite the quarry of the Miramichi Quarry Co. Apparently the top beds exposed in the latter quarry, are missing in this quarry and consequently only the thicker beds are exposed. This stone is very similar in texture and composition to that which is found in the lower beds of the Miramichi quarry. The sample for testing was taken from the lowest beds. (Sample No. 5.)

Torryburn, N.B.

An outcrop of sandstone occurs at tide level, on the shore of Kennebecasis bay, to the west of Hasting's cove, and north of Torryburn station on the Canadian Government Railway line from St. John to Moncton. This outcrop rises to a height of about 20 feet at a distance of 50 yards from the shore. The rock is exposed a distance of about 300 feet along the shore, and the beds have an average dip of approximately 35° to the southwest.

No quarrying has been done on this outcrop, hence no idea can be obtained as to whether blocks of sufficient size for pulpstones could be quarried. The rock varies in character in different parts of the exposure; from a badly shattered stone spotted with iron stains, through a medium grained gritty stone fairly clean and uniform, to a compact, close-grained, and very brittle rock which is practically a quartzite. The outcrop extends about 200 yards back from the shore. Similar rock outcrops about $\frac{1}{4}$ to $\frac{1}{2}$ of a mile inland. The sample for testing was taken from the medium grained gritty stone at the shore. (Sample No. 6.)

C. W. Dean Property, Adamsville, N.B.

This property was not visited by the writer, but the sample for testing was furnished by Mr. Dean, who refers to this occurrence as follows:—

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PLATE IV.

View showing sandstone beds, Adam Hill's Quarry, on northwest Miramichi river, N.B.

PLATE V.

View in Miramichi Quarry Co's. quarry, showing upper sandstone beds and thickness of overburden.

> The sample is a piece picked up from a slide which occurred last summer.
>
> The bed referred to is of immense size; there are three layers totalling 20 feet high, also several layers not so thick; the total deposit measures at least 50 feet high and extends over the whole district.
>
> The outcrop is on the branch of the Coal Branch river, which would afford an excellent dump for the waste rock and soil of which there is only about 4 feet.
>
> There is no doubt as to getting stones of the required dimensions; I measured two blocks as follows";
>
> 40" by 60" by 120".
> 40" by 32" by 70".

From Mr. Dean's description it would appear that rock of sufficient size for pulpstones in a considerable quantity can be obtained from this locality. (Sample No. 12.)

Smith Quarry, (Dr. E. G. Smith), Shediac, N.B.

The Smith quarry is situated to the south of the Canadian Government Railway, about a mile west of Shediac station. The quarry is opened up for a distance of about 200 feet along the east bank of the Shediac river, and has been worked back from the river for a depth of 100 feet. The face at present is over 75 feet high. Only the lower beds are of sufficient thickness to furnish blocks of suitable size for the manufacturing of pulpstones. The rock, however, is very uniform throughout, and like all the other sandstones of the Maritime Provinces has the quality of working readily when green, and hardening remarkably on being seasoned. The sample for testing was taken from the lower beds. (Sample No. 7.)

Valentine Hickey Property, Stake Road P.O., N.S.

About one mile to the north of Stake Road P.O. on the farm of Valentine Hickey there is an outcrop of sandstone about 3 feet thick dipping about 60° to the south. The stone as far as could be seen was very uniform in character, but little could be told concerning the deposit owing to only a small portion of the beds being exposed. A sample was taken for testing. (Sample No. 8.)

Morristown Quarry, Antigonish, N.S.

The sample from this quarry was furnished for testing by Mr. A. R. Chambers of New Glasgow, N.S., and the property was not visited by the writer. This quarry is situated on the Bay of St. George near the Morristown wharf. (Sample No. 11.)

In all the above mentioned localities in the Maritime Provinces, the freshly quarried rock is comparatively soft, but hardens rapidly on exposure to the air. This greatly lessens the cost of production as it enables the blocks to be chipped and shaped with comparative ease.

METHOD OF MANUFACTURING PULPSTONES.

The preparation of a pulpstone for the market requires very little machinery. The block after being quarried in a sufficient size, is roughly chipped and chiselled with a few inches to spare on all dimensions. The hole through the centre for the shafting is then cut, and the stone placed on a 4 to 6 inch shafting, belted to some driving power. The stone is firmly fastened to this shafting by means of large flanges, and revolved rapidly. Then, a large shaping chisel is pressed against the face turning it to the required size: an operation similar to wood-turning on a lathe. When finished, the stone is stored and allowed to "season," preferably for a year. When shipping, it is preferable to crate the stone to prevent the cutting face from being chipped and damaged.

TESTS TO WHICH SAMPLES WERE SUBJECTED.

In an investigation of this nature it is not practicable to obtain full size working specimens and to watch their behaviour under actual working conditions. This method naturally would be the best way to determine whether a sandstone is suitable for pulpwood grinding. Much information of value, however, can be gained from tests made on small specimens in the laboratory, and from the results obtained one can readily determine whether a sandstone would be worth testing out on a full sized stone.

In order to obtain comparative results of value, seven pieces of imported pulpstones which had been used and had proved satisfactory, were obtained from three Canadian pulp companies, and these samples were submitted to the same tests as were the samples obtained from Canadian localities. By taking the average results obtained from the imported stones and comparing the results obtained for the Canadian samples with this average, an idea as to the value of the Canadian material for this purpose can be obtained. The tests to which the samples were subjected were:—

Granulometric Analysis.

A small portion of each sample was carefully crushed by hand in an earthenware mortar, great care being exercised so as not to crush the sandstone grains, and yet not to leave any group of grains still cemented together. When the sample was broken down completely into its original individual grains, 100 grams was weighed out and screened through a set of Tyler Standard Screens. The results obtained from this test give one an idea of the texture of the stone with regard to the size of grain. The test is carried out as follows:—

The 100 gram sample is placed in the coarsest screen, which is nested into the next size finer, and so on down to the 200 mesh, and retaining pan on bottom. The nest of screens is then thoroughly shaken on a mechanical shaker: the material retained on each screen being collected, weighed, and noted. The sample in the first place being 100 grams, the weight recorded as retained on each screen is the percentage retained on that screen; and the cumulative per cent, or the percentage of all the material that would be retained on any given screen, if that screen alone were employed, can readily be determined. The screens for this test and the form used for tabulating the results are as follows:—

Indicate the screen crushed through and also first retaining screen	SCREEN SCALE RATIO 1·414				WEIGHTS		
	Openings		Mesh	Diameter Wire. Inches	Sample weights	Per cent	Per cent Cumulative Weights
	Inches	Millimetres					
....	1·050	26·67		·149	....	....	....
....	·742	18·85		·135	....	....	....
....	·525	13·33		·105	....	....	....
....	·371	9·423		·092	....	....	....
....	·263	6·680	3	·070	....	....	....
....	·185	4·699	4	·065	....	....	....
....	·131	3·327	6	·036	....	....	....
....	·093	2·362	8	·032	....	....	....
....	·065	1·651	10	·035	....	....	....
....	·046	1·168	14	·025	....	....	....
....	·0328	·833	20	·0172	....	....	....
....	·0232	·589	28	·0125	....	....	....
....	·0164	·417	35	·0122	....	....	....
....	·0116	·295	48	·0092	....	....	....
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Pass............	·0029	·047	200	·0021	....	....	....
				Totals,	....	....	....

To gain an idea of the fineness of the grain of the stone, by way of comparison, and to be able to express this in one figure, the average fineness of the sample is calculated. This is determined as follows: the quantity of material passing through each screen and retained on the next smaller is multiplied by the mesh of the screen passed through. The results thus obtained are totalled, and divided by 100, the final result being the average fineness. In other words, if all the grains of the sample were reduced to a uniform size, they would just pass through a screen whose mesh was equal to the average fineness of the sample.

Hardness Test.

The hardness or abrasive quality of the samples was tested on a Dorry Hardness Machine. Cylinders 1 inch diameter were obtained by means of a diamond drill, from the sample blocks of sandstone. One end of each cylindrical test piece is pressed against a horizontally revolving plate, on which is spread standard quartz sand. The core and holder is weighted to 1,250 grams, and the machine allowed to run for 500 revolutions. The test piece is weighed before and after the test and the figures given in the table are the number of grams lost due to the grinding action of the quartz sand.

Toughness Test.

The strength of the sample to resist sudden strains, etc., was tested by impact. In this test, cylinders 1 inch diameter and 1 inch high were cut from the diamond drill cores, and tested on a Page Impact Machine. On this machine, the blow from a two kilogram hammer, dropping from heights increasing by 1 centimetre after each blow, is transmitted to the test cylinders by a steel plunger having a spherical end resting on the cylinder. The height of the last drop of the hammer expressed in centimetres is the figure taken as representing resistance to shock and is given in the table.

Microscopic Examination for Structure.

With a view to studying the texture and composition, each of the samples of the various stones were examined under a binocular microscope and the results duly tabulated.

Microphotographs were also taken of the surfaces of the cylinders after the hardness test.

RESULTS OF TESTS.

Seventeen samples in all were examined, seven being imported pulp stones, and ten Canadian sandstones. The localities from which these samples were obtained were:—

1. English Pulpstone, Booth Lumber Co.
2. American Pulpstone, Booth Lumber Co.
3. Hill's Quarry, Northwest Miramichi river, N.B.
4. The Miramichi Quarry Co., Quarryville, N.B.
5. The Read Stone Co., Quarryville, N.B.
6. Torryburn Sandstone, near St. John, N.B.
7. Smith Quarry, Shediac, N.B.
8. Sandstone, Stake Road P.O., N.S.
9. American Pulpstone, E. B. Eddy Co.
10. Read Stone Co., Stonehaven, N.B.
11. Morristown Quarry, Antigonish, N.S.
12. Dean Property, Adamsville, N.B.
13. Higginson Quarry, Hawkesbury, Ont.
14. English Pulpstone, E. B. Eddy Co.
15. English Pulpstone, Laurentide Co.
16. American Pulpstone, Laurentide Co. (Empire, Ohio.)
17. American Pulpstone, Laurentide Co. (W. Virginia.)

TABLE I.

Granulometric Analyses: Samples of Canadian Pulpstones and Imported Stones.

Retained on	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
10 mesh	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
14	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
20	—	—	—	—	—	·22	—	—	—	—	—	—	—	—	—	—	—
28	1·60	7·80	—	9·75	—	3·55	3·85	—	—	—	—	—	—	—	9·55	3·65	2·86
35	16·30	17·65	4·10	21·57	33·27	18·55	14·78	8·18	12·27	—	6·70	·07	—	1·50	14·83	14·56	9·04
48	42·35	34·87	24·83	36·86	36·49	40·90	42·97	40·65	38·96	3·20	18·65	6·60	—	22·30	27·20	40·85	43·15
65	14·28	15·05	30·13	12·43	11·55	15·85	17·05	18·39	16·77	6·39	23·55	14·14	6·57	29·96	16·27	12·14	18·55
100	7·67	8·00	20·18	6·32	6·36	8·24	7·97	14·35	11·30	30·65	17·85	37·00	10·85	19·80	17·55	9·25	10·01
150	4·35	4·10	6·97	2·98	2·85	4·75	4·55	4·20	5·25	31·85	14·95	21·16	24·58	8·80	5·90	5·25	4·24
200	1·85	1·75	3·29	2·57	1·87	2·05	1·95	6·20	2·45	9·10	5·75	6·20	24·49	3·22	2·02	2·58	1·85
Through 200 mesh	11·45	10·57	10·48	7·16	7·49	5·55	6·49	7·89	12·85	18·55	12·35	14·65	33·25	14·35	6·50	11·37	10·07
Total.......	99·85	99·79	99·98	99·64	99·88	99·66	99·61	99·86	99·85	99·74	99·80	99·82	99·74	99·93	99·82	99·65	99·77
Loss or gain.	—·15	—·21	—·02	—·36	—·12	—·34	—·39	—·14	—·15	—·26	—·20	—·18	—·26	—·07	—·18	—·35	—·23

TABLE II.

Cumulative Percentages of Canadian and Imported Pulpstones.

Retained on	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
10 mesh	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
14	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
20	—	—	—	—	—	·22	—	—	—	—	—	—	—	—	—	—	—
28	1·60	7·80	—	9·75	—	3·77	3·85	—	—	—	—	—	—	—	9·55	3·65	2·86
35	17·90	25·45	4·10	31·32	33·27	22·32	18·63	8·18	12·27	—	6·70	·07	—	1·50	24·38	18·21	11·90
48	60·25	60·32	28 93	68·18	69·76	63·22	61·60	48·83	51·23	3·20	25·35	6·67	—	23·80	51·58	59·06	55·05
65	74·53	75·37	59·06	80·61	81·31	79·07	78·65	67·22	68·00	9·59	·96	20·81	6·57	53·76	67·85	71·20	73·60
100	82·20	83·37	79·24	86·93	87·67	87·31	86·62	81·57	79·30	40·24	66· 5	57·81	17·42	73·56	85·40	80·45	83·61
150	86·55	87·47	86·21	89·91	90·52	92·06	91·17	85·77	84·55	72·09	81·70	78·97	42·00	82·36	91·30	85·70	87·85
200	88·40	89·22	89·50	92·48	92·39	94·11	93·12	91·97	87·00	81·19	87·45	85·17	66·49	85·58	93·32	88·28	89·70
Average fineness	61·67	59·13	70·30	52·35	52·48	52·36	54·02	64·04	67·19	106·88	79·71	93·04	138·19	77·85	56·85	63·03	60·92

TABLE III.

Hardness Test.

Loss in grams	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
500 revs. 1st	17·3	18·8	29·5	20·5	20·9	6·7	31·2	20·9	25·8	28·5	83·8	33·9	22·7	23·6	10·3	30·8	21·2
2nd	16·8	19·5	29·5	21·5	20·8	4·3	30·3	26·0	25·5	28·5	84·3	31·5	22·6	25·4	13·4	31·1	20·4
Average.....	17·1	19·1	29·5	21·0	20·8	5·5	30·8	23·5	25·6	28·5	84·0	32·7	22·6	24·5	11·9	30·9	20·8

Average hardness of Imported Stones = 21·4 grams.

TABLE IV.

Toughness Test.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1st	5	5	4	4	3	8	4	4	3	5	2	3	9	4	6	4	5
2nd	5	5	3	4	3	8	4	4	3	5	2	3	9	4	6	4	4
3rd	4	4	3	4	2	6	3	4	3	5	2	3	8	4	6	3	4
4th	4	4	3	—	—	6	—	—	—	—	—	—	—	—	—	—	—
Average.....	4·5	4·5	3	4	2·7	7	4	4	3	5	2	3	8·7	4	6	·37	4·3

Average height of drop of Imported Stones = 4·3 cm.

	10	11	12	17
Colour.	grey.	Blue-grey.	Brownish-whit	Creamy-white.
Characte of grains	angular.	Angular to semi-angular.	Angular to semi-angular.	Semi-angula
Composi of grains	tz ional ar nica.	Quartz and lime grains.	Quartz feldspar and mica.	Quartz occasional mica.
Composi of matri	aceous ½ of	Calcareous ½ at e.	Argillaceous.	Calcareous.

TABLE

Microscopic E

	1	2	3	4	5	6	7	8	
Colour.	Light-brownish-white.	Creamy-white.	Light-yellowish-green.	Yellowish-green to grey.	Yellowish-green to grey.	Pinkish-white.	Light-greenish.	Brownish-white.	Lig whi
Character of grains.	Semi-angular and crystalline.	Semi-angular.	Angular to semi-angular.	Angular to semi-angular.	Angular to semi-angular.	Rounded.	Angular.	Semi-angular to rounded.	Rou sem ang
Composition of grains.	Principally quartz and occasional hornblende.	Quartz occasional iron specks.	Quartz feldspar mica	Quartz feldspar mica flakes.	Quartz feldspar mica flakes.	Quartz occasional iron specks.	Quartz altered feldspar and chlorite.	Quartz feldspar occasional iron specks and mica.	Qua occa horn and spec
Composition of matrix.	Calcareous.	Siliceous.	Argillaceous.	Argillaceous.	Argillaceous.	Siliceous.	Argillaceous slightly calcareous.	Siliceous slightly carbonaceous.	Silic

TABLE V.

copic Examination.

	9	10	11	12	13	14	15	16	17
ish-	Light-brown white.	Blue-grey.	Blue-grey.	Brownish-white.	Grey.	Brownish-white.	Brownish-white.	Light-greenish-white.	Creamy-white.
ngular ded.	Rounded to semi-angular.	Semi-angular.	Angular to semi-angular.	Angular to semi-angular.	Angular.	Semi-angular	Angular.	Semi-angular.	Semi-angular
al ecks a.	Quartz occasional hornblende and iron specks.	Quartz occasional feldspar and mica.	Quartz and lime grains.	Quartz feldspar and mica.	Quartz occasional feldspar.	Quartz occasional feldspar and mica.	Quartz feldspar mica iron specks.	Quartz occasional feldspar and mica.	Quartz occasional mica.
car- us.	Siliceous.	Argillaceous about ½ of stone.	Calcareous ½ stone.	Argillaceous.	Argillaceous.	Siliceous.	Siliceous.	Siliceous.	Calcareous.

The results of the granulometric analyses, cumulative percentages, and average fineness are given in Tables I and II. From Table II, by taking all the results for the imported stones, and obtaining an average, figures were obtained from which the heavy curve in Fig. 4 was plotted. This curve, therefore, represents the average cumulative result of screen analyses of the seven imported samples. On the same diagram are plotted the curves of the ten Canadian samples for purposes of comparison.

Tables III and IV give the results obtained by the hardness and toughness tests. The average of the results of the imported stones are in each case noted for purposes of comparison. Table [illegible] gives in tabulated form the results of the microscopic examination of the samples. Plate VI shows the relative cutting qualities of the seventeen samples.

CONCLUSIONS.

In summing up the results to be drawn from the data obtained in these tests certain tentative specifications can be stated in a general way.

The tests carried out gave remarkably similar results for all the seven imported stones; so that it may be reasonably assumed that a stone, giving test results approximating to the average of imported stones, should be a likely stone from which to make pulpstones. It will be seen by closely studying the tables, and noting the results, that several of the Canadian samples compare very favourably with the standard average. With a little co-operation between the owners of prospective quarries, and consumers of pulpstones, an industry in this product could soon be firmly established in Canada.

The results obtained in this investigation lead one to believe that there are great possibilities for largely extending the pulpstone industry in Canada, which now is only of small proportion. Little encouragement has been given the producers of Canadian stones by the consumer, and when such stones have been purchased sufficient time has not been allowed to ensure securing stones which were properly seasoned. With proper encouragement and consideration from the pulpstone consumers, the pulpstone industry should show a marked improvement in the next few years. The tests already conducted, both in labatory and on a commercial scale, tend to show that pulpstones having thereon the legend "Made in Canada" can be placed on the Canadian and the United States markets with every confidence that they will prove equal to the best imported stones.

TO THE MANUFACTURER.

Great care should be taken in the selection of the blocks for pulpstones. They should be absolutely free, as far as can be seen from a careful examination of the outside, from seams, cracks, or "bulls." Above all, see to it that the finished stones are "seasoned" under cover at the quarry, for at least a year, if possible, before selling; and crate well for shipment.

TO THE CUSTOMER.

Endeavour to purchase only seasoned stones. And when Canadian stones are purchased, test them with an open mind as to how they behave under working conditions; in other words, give them every chance to prove their suitability by centering them with extreme care; running them light, until uniformly heated, and take all the reasonable precautions usually followed in good practice.

SUGGESTED COURSE FOR FUTURE INVESTIGATION.

The results achieved in this investigation have shown the great opportunity there is for valuable experimentation in connexion with the mechanical grinding of wood pulp. The present practice is, to use a solid stone, of which, only about 14 to 16 inches of the face is worn off in the grinding process; the greater bulk of the stone being then discarded. This is manifestly a wasteful method. The possibility, therefore, of manufacturing an artificial stone suitable for this work, seems to be worthy of study. The points to be ascertained in an investigation along this line would be to obtain a cement sufficiently hard, and capable of withstanding the severe stresses and high temperature to which a pulpstone is subjected. If this were accomplished, the centre part of the stone could be made permanent, and only the outer grinding surface would have to be renewed.

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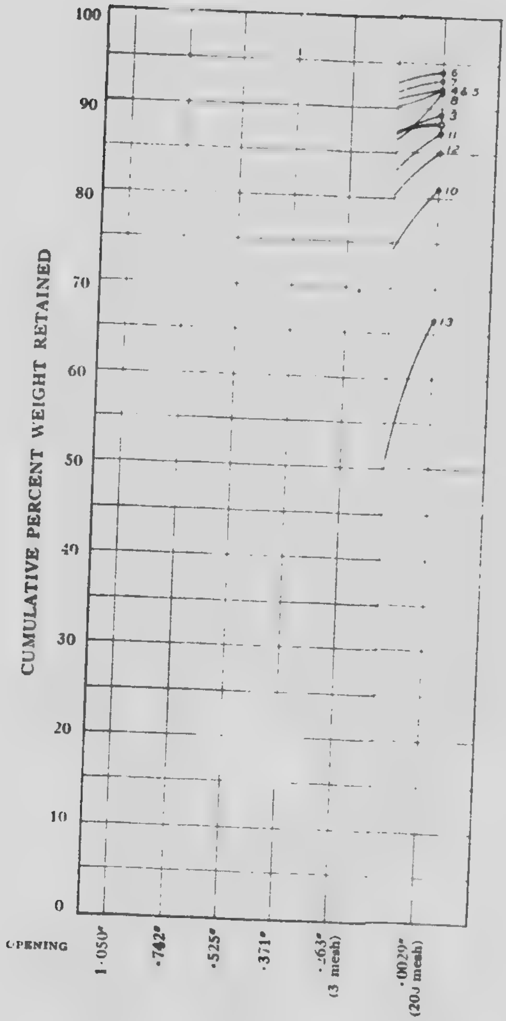


Fig. 4. Graphic c parisoɴ of

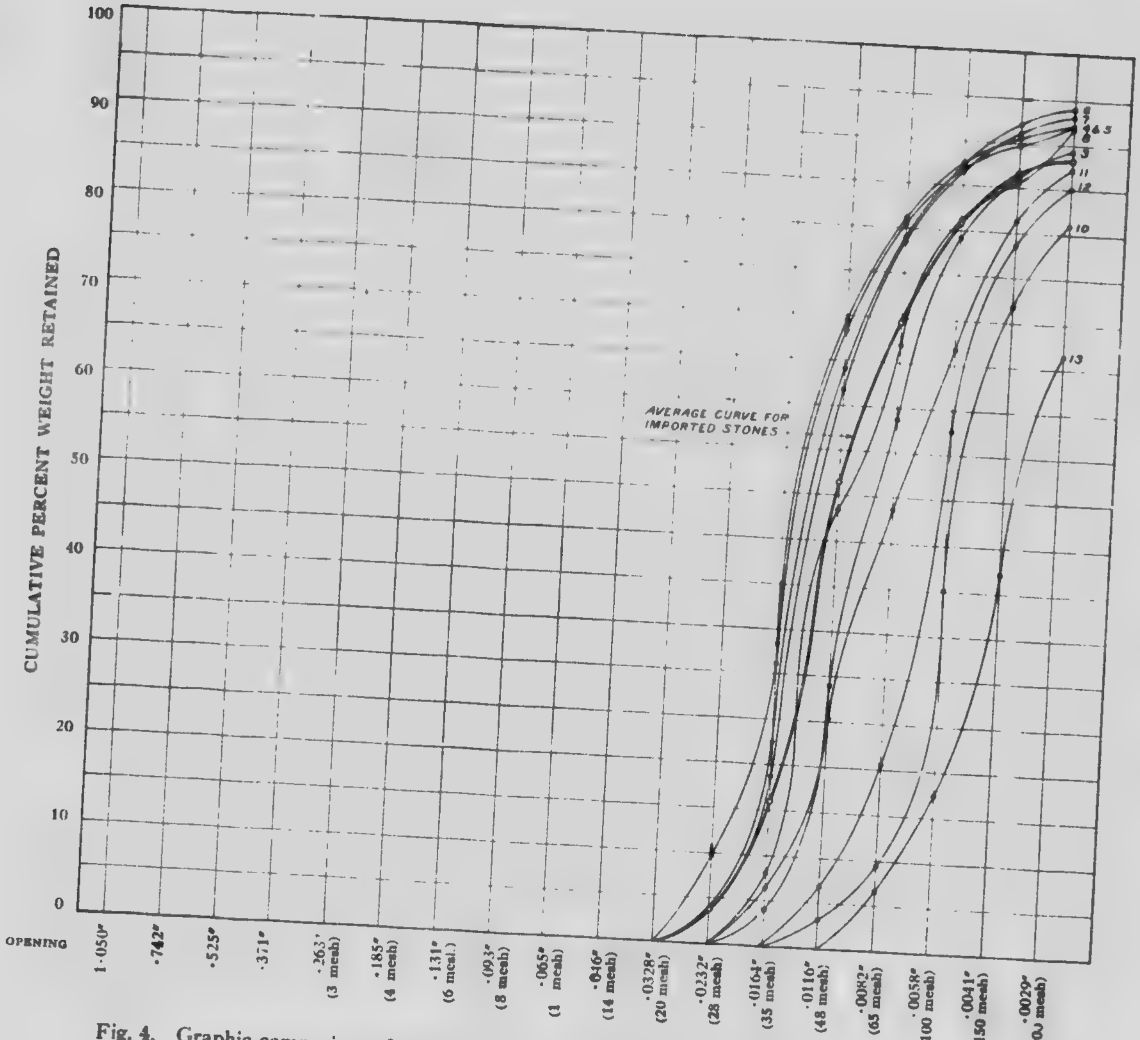
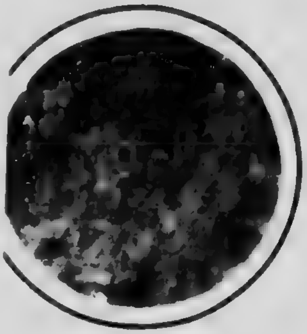


Fig. 4. Graphic comparison of screen analyses of Canadian sandstones, with average analysis of seven imported stones.

PLATE VI



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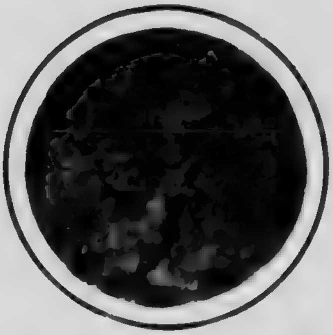

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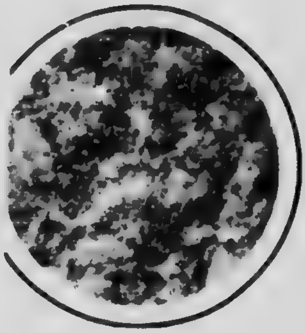

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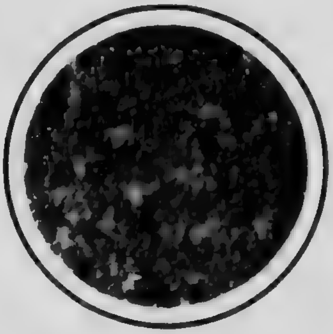

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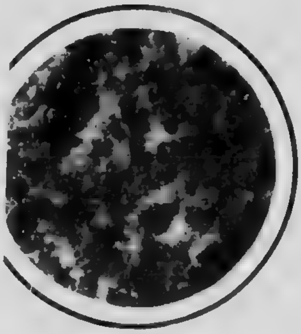

17

Microphotographs of grinding faces of Canadian sandstones and imported pulpstones, showing relative grinding qualities.

Magnification: 12 diameters.

Oblique reflected light.

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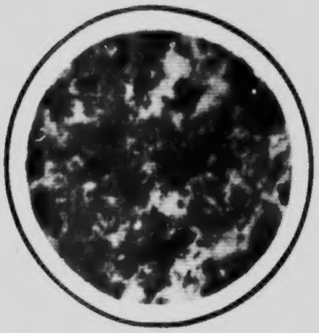

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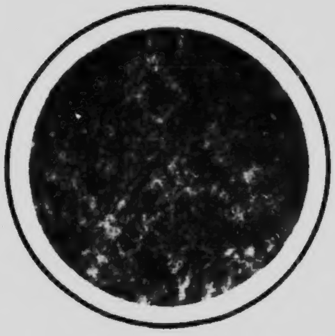

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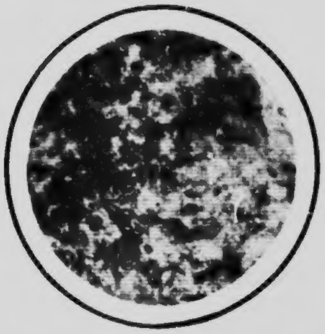

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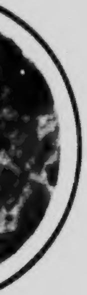
PLATE VI



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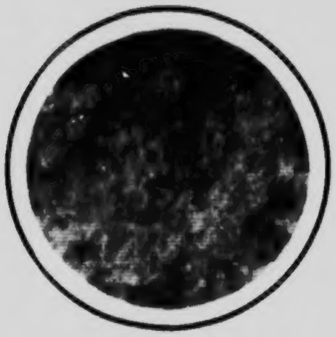

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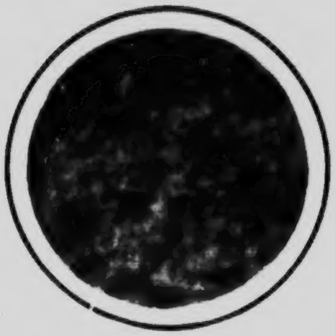

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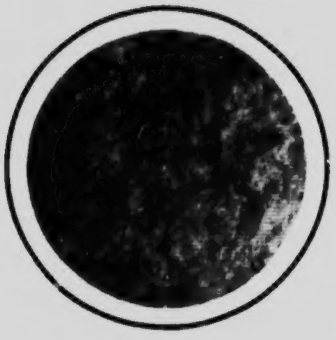

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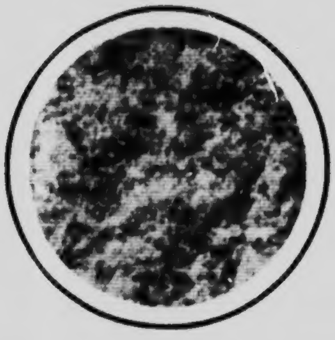

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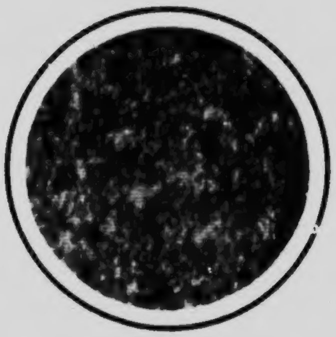

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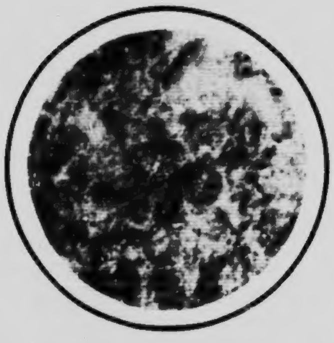

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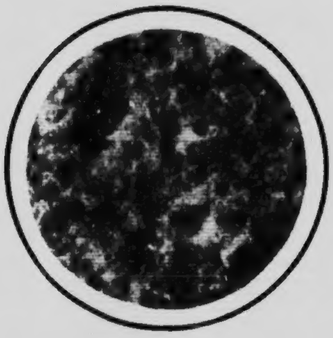

17

Microphotographs of grinding faces of Canadian sandstones and imported pulpstones, showing relative grinding qualities.

Magnification: 12 diameters.

Oblique reflected light.

INDEX.

A

Adam Hill quarry, Cassils, N.B. 7

C

Chambers, A. R.—sample furnished by 9
Conclusions 15

D

Dean, C. W.—sandstone property 8

G

Granulometric analyses 10, 13

H

Hardness test 11, 14
Hawkesbury: sandstone quarry at 6
Hickey, Valentine, property 9
Higginson, J. C.—sandstone quarry 6

I

Introductory 1
Indiantown quarry 8

M

Maritime Provinces: sandstone deposits in 6
Microscopic examination for structure 12, 14
Miramichi Quarry Co 7
Morristown quarry 9

O

Ontario: few sandstones suitable 6

P

Pulpgrinding: method of 1
Pulpstones: Canadian 5
    „ method of manufacturing 9
    „ properties required 4
    „ work required of 1

Q

Que [illegible] suitable sandstone found 6

R

Read Stone Co 7, 8

S

Smith quarry (Dr. E. G. Smith) 9
Stonehaven quarries 7
Suggestions 16

T

Table I. Granulometric analyses 13
    „ II. Cumulative percentages 13
    „ III. Hardness test 14
    „ IV. Toughness test 14
    „ V. Microscopic examination 14
Tests: results of 12
    „ to which samples were subjected 10
Torryburn, N.B.—sandstone outcrop 8
Toughness test 11, 14